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(71) Applicant
Sulzer-Mtu-Casting Technology GmbH

(Incorporated in the Federal Republic of Germany)

Postfach 50 06 40, D-8000 München 50, Dachauer Strasse 665, Federal Republic of Germany

(72) Inventors
Fritz Staub
Daniel Stahl
Jurgen Wortmann

(74) Agent and/or Address for Service
Withes & Rogers
4 Dyer's Buildings, Holborn, London, EC1N 2JT, Untied Kingdom

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B22D 27/04

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(56) Documents cited
GB 1307208 A EP 0477136 A1 EP 0126550 A1
US 4774992 A

(58) Field of search
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INT CL[5] B22D
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(54) Casting of directionally solidified articles using a plurality of moulds

(57) A casting unit for producing a plurality of cast parts by means of directional solidification or single crystal formation and having a shell mould 12 comprises a plurality of individual moulds, 10 and has a cooling plate 20 which forms a lower closure of the shell mould 12 is characterised in that the individual moulds 10 of the shell mould 12 are disposed in a regular grid at slight distances from one another, and the assembly of individual moulds 10 is surrounded by a ring of heat sources 11 integrated in the shell mould 12. In this way a large number of cast parts can be cast simultaneously whilst keeping the structural space to a minimum.

The entire casting unit may be surrounded by reflectors in order to control the development of the temperature.

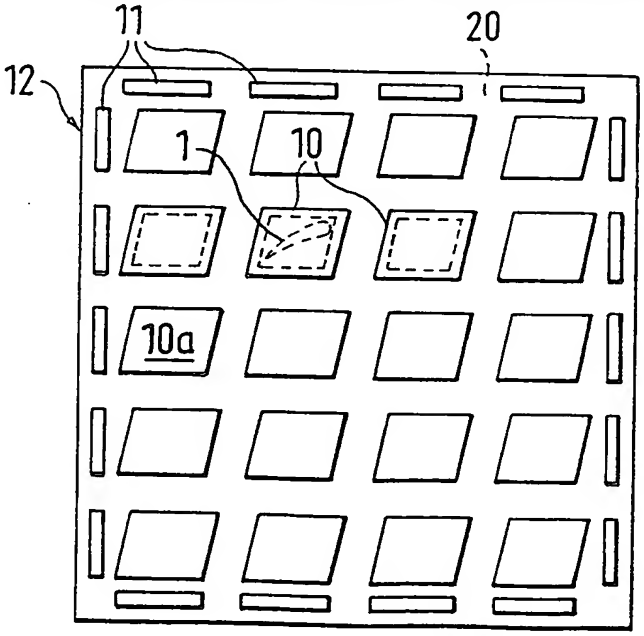

FIG.2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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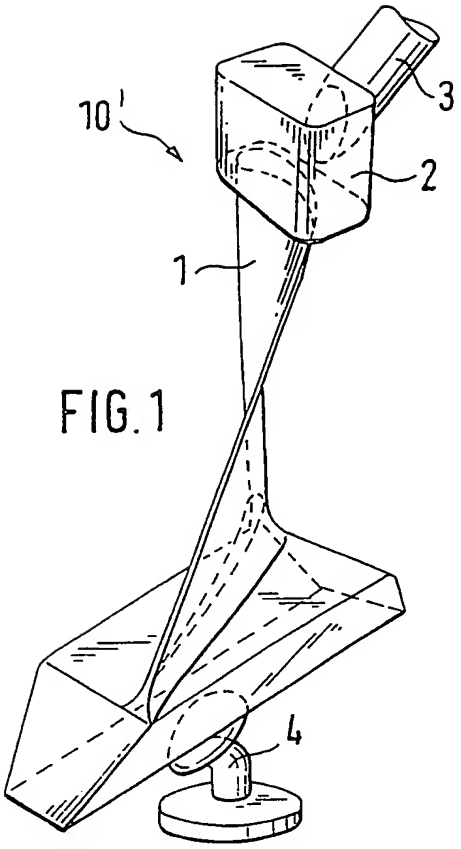

FIG. 1

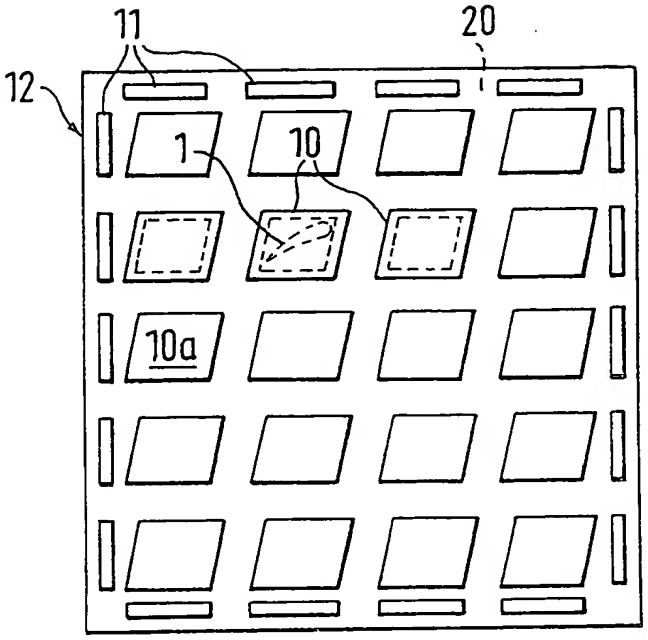

FIG. 2

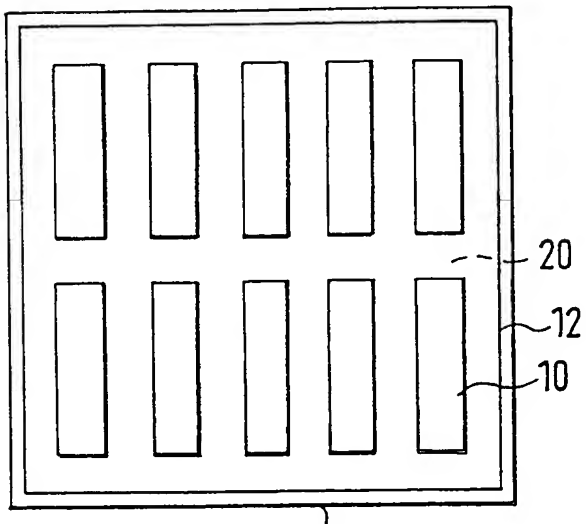

FIG. 3

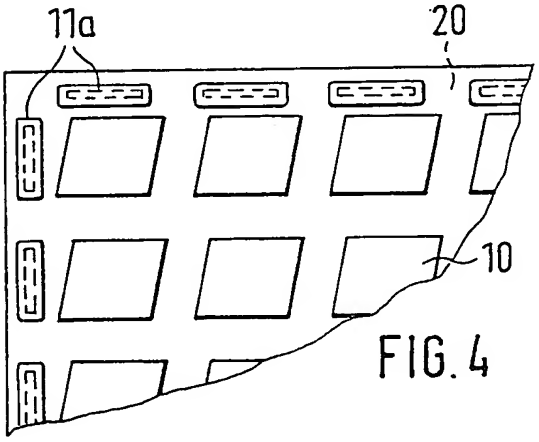

FIG. 4

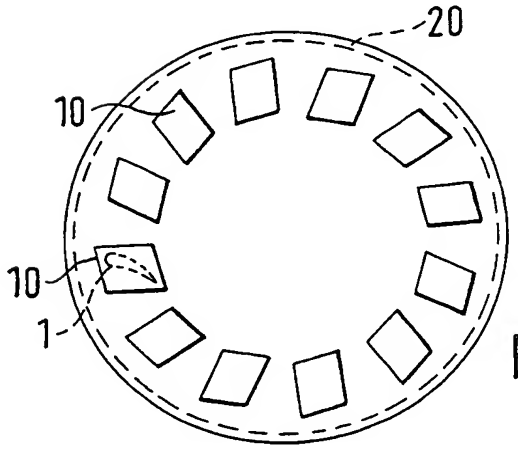

FIG. 5

Casting unit for producing a plurality of cast parts

The invention relates to a casting unit for producing a plurality of cast parts by means of directional solidification or single crystal formation and having a shell mould which comprises a plurality of individual moulds corresponding to the cast parts and having a cooling plate which forms a lower closure for the shell mould, as well as to a process using a casting unit of this type.

EP-A-0 477 136 discloses a casting unit of the initially mentioned type. This publication describes a casting unit in the case of which the individual cast parts are disposed in the manner of a bunch of grapes in circular fashion about a central stalk. The central arrangement of the individual moulds ensures that the same conditions exist for all the cast parts with respect to the heating capacity on solidification and thus that the control of the solidification front is identical for each cast part. As a result thereof the same level of quality can be achieved for each cast part. One disadvantage of the known casting unit resides in the fact that, when the number of individual moulds per casting unit is to be increased in order to improve economic efficiency

during casting, the diameter of the casting unit has to be increased as a result of which larger and thus more expensive furnaces are required. On the other hand, a free space which remains unused is produced inside the individual moulds disposed in a circular manner. If it were also desired to dispose individual moulds in this internal free space, it would not be possible to meet the requirement of all the individual moulds or casting parts having the same heating capacity during solidification without further measures being used. In order to overcome this problem, US-PS 3 763 926 discloses cooling the individual moulds by means of a tin melt as a result of which considerable manufacturing expenditure is however incurred.

It is therefore the object of the present invention to provide a casting unit of the initially mentioned type of construction in which the greatest possible number of cast parts can be produced simultaneously and with low structural expenditure.

In accordance with the invention the stated object is achieved in that, in the case of a casting unit of the initially mentioned type, the individual moulds of the shell mould are disposed in a

regular grid with slight distances maintained between them, and the assembly of individual moulds is surrounded by a ring of heat sources integrated in the shell mould.

The essential advantage of the casting unit according to the invention resides in the fact that, by means of the arrangement of the individual moulds in a regular grid, a maximum number of individual moulds, and thus cast parts, can be cast in a predetermined area and thus a predetermined structural space, the heat sources integrated in the periphery of the shell mould being used to compensate the heating capacity of the individual moulds of which the edges are in the peripheral area.

In the case of a first preferred embodiment of the casting unit according to the invention, the heat sources are in the form of accumulations of material in the edge area of the shell mould. The edge area of the shell mould can have locally increased heating capacity as a result of the accumulations of material and thus control the development of the temperature in the solidifying cast part as a heat reservoir or heat source.

In a further development of the invention, the heat sources integrated in the shell mould can be hollow bodies which can be filled with melt. The heating capacity of the hollow bodies can be adjusted precisely by means of the size of the hollow bodies and thus the development of the temperature in the solidifying cast part can be controlled very well.

Preferably the heating capacity of the heat sources is adapted to the heating capacity of the casting unit in such a way that the lateral influx of heat to the individual moulds of the shell mould of which the edges are in the peripheral area is at least approximately the same from the outside and the inside. The influx of heat from the inside to the individual moulds of which the edges are in the peripheral area thus results from the adjacent individual moulds in the central area of the casting unit.

The invention further relates to a process for producing cast parts by means of directional solidification or single crystal formation in a vacuum casting plant. A casting process of this type is again disclosed in EP-A 0 477 136. An essential feature of a process of this type consists in generating a controlled flow of heat

in order to steer the solidification front such that directional solidification or single crystal formation is thus brought about. It is known to generate a controlled flow of heat of this type by using heating elements with an external energy supply (susceptors).

The present invention improves a process of this type according to the invention in that a casting unit according to any one of Claims 1 to 4 is used. As a result, heating elements with an external energy supply are superfluous and yet the flow of heat and thus the development of the temperature in the solidifying cast parts can be controlled precisely.

Preferably, in the case of the process according to the invention, the casting unit is heated before casting, externally of the vacuum casting plant, to a temperature which is at least 50K higher than the liquid temperature of the casting material.

In a further development of the process according to the invention, the development of the temperature can be controlled when the melt is solidifying by isolating the individual moulds of the casting unit. Finally, in a further

development of the process according to the invention, the development of the temperature is controlled by reflectors which surround the casting unit and thus reflect the heat radiated thereby in particular to the individual moulds of which the edges are in the peripheral area.

The invention will be described in further detail by means of embodiments with reference to the enclosed drawing, in which:

Figure 1 shows the wax mould of a cast part to be produced, in this case a turbine blade;

Figure 2 shows schematically a cross-section through a first basic embodiment of the shell mould of a casting unit according to the invention;

Figure 3 shows an alternative embodiment of a shell mould in an illustration corresponding to Figure 2;

Figure 4 shows a cut-away section on an enlarged scale of a cross-section according to Figure 2, however with hollow bodies disposed in the edge area of the shell mould for accommodating melt; and

Figure 5 shows a cross-section according to Figure 2 of a casting unit with individual moulds arranged in circular fashion according to the prior art.

The turbine blade shown in Figure 1 as a wax model 1 is to be produced as a single crystal cast part. At the top of the turbine blade the wax mould comprises a heat reservoir 2 and a delivery duct 3 and at the blade foot a so-called selector 4 which is necessary for forming a single crystal.

Figure 2 shows a schematic cross-section of a casting unit for producing a plurality of blades according to Figure 1. The casting unit comprises a shell mould 12 which comprises a plurality of individual moulds 10 corresponding to the wax models 1. As shown in the Figure, the individual moulds 10 are disposed in a rectangular grid with slight distances maintained between them. In this respect, the delivery ducts 3 of the individual moulds are combined to form a common casting duct, ie. the shell mould 12 is open at the top. The shell mould 12 is also open at the bottom and is mounted directly on a cooling plate 20 with which the melt comes into direct contact. For casting, the casting unit is placed in a vacuum casting plant (not illustrated). The assembly of

individual moulds 10 is surrounded by a ring of heat sources 11 which are integrated in the shell mould 12 and, with respect to their heating capacity, are adapted to the heating capacity of the casting unit in such a way that the lateral influx of heat to the individual moulds 10a of the shell mould 12 of which the edges are in the peripheral area is at least approximately the same from the outside and the inside. As a result of the heat sources 11 therefore, a precisely predetermined controlled flow of heat is generated in order to control the solidification front as required. In the case of the first embodiment according to Figure 2, the heat sources 11 are simply in the form of accumulations of material in the edge area of the shell mould 12 which may be sufficient since the shell moulds are generally made of ceramics and thus have sufficient heating capacity. Alternatively, as shown in Figure 4, the heat sources may also be in the form of hollow bodies 11a which can be filled with melt. In this respect the heating capacity of the melt is used predominantly as the heat source for generating a controlled flow of heat.

Finally, a process for casting directionally solidified cast parts in which a casting unit as described above is used for controlling the

development of the temperature as the melt solidifies can also make use of the isolation of the individual moulds of the casting unit, or the entire casting unit can be surrounded by reflectors 14 in order to control the development of the temperature, as shown in Figure 3 for example. In this respect the casting unit does not have to be surrounded uniformly on all sides by reflectors 14, the partial arrangement of reflectors on the periphery of the casting unit can also produce the desired controlled flow of heat in particular when the cast parts are of the type indicated in Figure 3, namely having plate-like geometry.

Finally, it should be stated that a process according to the invention for producing cast parts by means of directional solidification or single crystal formation includes heating the casting unit before casting, externally of the vacuum casting plant, to a temperature which is at least 50K higher than the liquid temperature of the casting material in order thus to impart to the casting unit a heating capacity which is sufficiently great for controlling solidification.

CLAIMS

1. Casting unit for producing a plurality of cast parts (1) by means of directional solidification or single crystal formation and having a shell mould (12) which comprises a plurality of individual moulds (10) corresponding to the cast parts (1), and having a cooling plate (20) which forms a lower closure for the shell mould (12), characterised in that the individual moulds (10) of the shell mould (12) are disposed in a regular grid at slight distances from one another, and the assembly of individual moulds (10) is surrounded by a ring of heat sources (11) integrated in the shell mould (12).

2. Casting unit according to Claim 1, characterised in that the heat sources (11) are formed as accumulations of material in the edge area of the shell mould (12).

3. Casting unit according to Claim 1 or 2, characterised in that the heat sources (11) are hollow bodies (11a) which can be filled with melt.

4. Casting unit according to any one of Claims 1 to 3, characterised in that the heating capacity of the heat sources (11) is adapted to

the heating capacity of the casting unit in such a way that the lateral influx of heat to the individual moulds (10a) of the shell mould (12) of which the edges are in the peripheral area is at least approximately identical from the outside and the inside.

5. Process for producing cast parts by means of directional solidification or single crystal formation in a vacuum casting plant, characterised in that a casting unit according to any one of Claims 1 to 4 is used.

6. Process according to Claim 5, characterised in that the casting unit is heated before casting, externally of the vacuum casting plant, to a temperature which is at least 50K higher than the liquid temperature of the casting material.

7. Process according to Claim 5 or Claim 6, characterised in that the development of the temperature is controlled as the melt solidifies by the isolation of the individual moulds of the casting unit.

8. Process according to Claim 5 or Claim 6, characterised in that the development of the

temperature is controlled as the melt solidifies by reflectors (14) surrounding the casting the unit.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
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Relevant Technical fields

(i) UK Cl (Edition L) B3F (FCP, FCU, FGK, FGM, FGP, FMH, FMK, FCXA, FCXB)

(ii) Int Cl (Edition 5) B22D

Search Examiner
P G BEDDOE

Databases (see over)
(i) UK Patent Office

(ii) ONLINE DATABASES: WPI

Date of Search
2 JULY 1993

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1307208	(TRW) see especially Claim 1; Figure 1; page 2 line 126 to page 3 line 95	1
X	EP 0477136 A1	(SULZER) see especially Claim 1; Figure 1	1
X	EP 0126550 A1	(AEPLC) see especially page 6 line 2 to page 7 line 15; Figure 4	1
X	US 4774992	(PCC) see especially column 3 line 59 to column 5 line 5; Figures 2, 4	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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